



Financial Engineering With Options and Its Implementation for Issuing of New Financial Innovations

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ABSTRACT

Purpose: The purpose of the paper is to focus on innovative structured products – investment certificates. The paper shows the creation techniques of a new discount basket certificate using two-asset correlation options, which play the central role in financial engineering. The possibilities of investment using given certificates are investigated for potential investors.

Methodology: Methodology of the paper is based on European style two-asset correlation options in analytical expression whose payoff is based on two underlying assets with two strike prices. Due to the lack of real-traded two asset correlation option data, own calculations of option premiums are processed in statistical program R. Also, the pricing of the new discount basket certificate is examined.

Approach: Theoretical value of the new discount basket certificate with different levels of its parameters on the stocks Facebook and Google is obtained and it is performed the analysis of the profitability for to the investor at the maturity date. Also, there is showed which parameters the investor should pay attention when deciding to invest into the given investment certificate.

Findings: Specific characteristics of each proposed certificate are pointed out and compared to each other with conclusion that every certificate can be the most profitable in specific price development of the underlying assets, but not in every price development. Ideas on how this certificate can be part of a personal investment portfolio are also presented.

INTRODUCTION

The term financial engineering is associated with innovation. It implies a search for new solutions to risk-management or investment problems, often a design of innovative products so called structured products. Structured products consist of multiple instruments that at least one is a de-

derivative, usually an option. Option components are important tools of financial engineering. Structured products offer to open positions in options or to implement complex option strategies without the option exchange access. The resulting products enable investors to make investments consistent with their market expectations and investment needs that cannot be satisfied by investing directly in the single investment.

Structured product, issued and sold by banks, became popular in Europe in the 1990s during a period of low interest rates. Nowadays, they are the fastest growing retail financial products in capital markets around the world. Despite the rapid growth of the market for structured products, very little research has been undertaken. For example, studies (Burth et al., 2001; Benet et al., 2006; Breuer and Perst, 2007; Bluemke, 2009; Rossetto and Bommel, 2009) deal with the structured products. The government issues different products such as government bonds or treasury bills for financing of its fiscal imbalance. Description of these classical tools is possible to find in the works of Rejnuš (2011) and Chovancová (2014). Let's suggest, that the issuing of investment certificates could be another way of gaining financial resources for covering of the fiscal imbalance. We focus on a design of new investment certificates, which can be used as the investments for investors or another side of gaining new financial resources for issuers (banks or governments).

An investment certificate is a type of structured product. As we have mentioned before, options are components of these products. The value of the option is derived from the value of an underlying asset in a specified way. The underlying asset is usually a stock in a company or an index, etc. The most popular certificates are certificates on indices which are now increasingly traded on a global scale. Linear, guaranteed, airbag, speed, discount, turbo, bonus certificates are some of the investment certificates. It can be stated that for every estimated development of an asset (growth, fall, stagnation) or for every attitude to risk (conservative or aggressive investor) there is a suitable kind of certificates.

The investment certificate is generally replicated with vanilla and/or exotic options. The replicated portfolio must have the same profit profile as the investment certificate. Hull (2012) defines vanilla option as a financial contract granting its holder (the buyer) the right, but not the obligation, to buy (call option) or sell (put option) a given underlying asset at a predetermined price (the strike price or the exercise price) of the option at any time within a specified expiration period of option (American style) or at the time of expiration of option (European style). For this right the option premium is paid to the option seller (the writer). Exotic options have some different characteristics compared to vanilla options, however the essential features are the same. More detailed descriptions of classic vanilla and exotic options exist in the literature (Nelken, 1996; Zhang, 1998; Haug, 2007). Profit functions in the analytical form of options and options strategies allow for expressing the trading and hedging option position (see, for example, Gordiaková and Lalić, 2014) and can be also used in investment certificate formation. Papers (Šoltés, 2010; Šoltés, 2011; Šoltés, 2012; Hernandez et al., 2013) dealt with the nature of the investment certificate formation using vanilla options. Authors Gordiaková and Younis (2013), Hernandez and Liu (2014) analyse the various types of investment certificates created by exotic options.

In this paper we propose the new discount basket certificate using the two-asset correlation options (the type of exotic options). To the best of our knowledge, no study has yet utilized two-asset correlation options to create the investment certificate. This work therefore contributes to the literature by filling this gap, including practical application on two underlying assets Facebook and Google. New discount basket certificates with various parameters are designed and analysed followed by investigation of their profitability.

First of all, a short overview of discount certificates and two-asset correlation options is presented. This is followed by a creation analysis of new discount basket certificate using two-asset correlation options. The final section contains the application on the internet industry.

1. THEORETICAL BACKGROUNDS

In the following part of the work we are going to pay attention to a discount certificate. The options which are used in the construction of discount certificates are the vanilla options. Their fundamental feature is the fact that the profit of the option depends only on the underlying asset value at the maturity date. This is followed by a two-asset correlation option introduction and its valuation analysis.

1.1 DISCOUNT CERTIFICATES

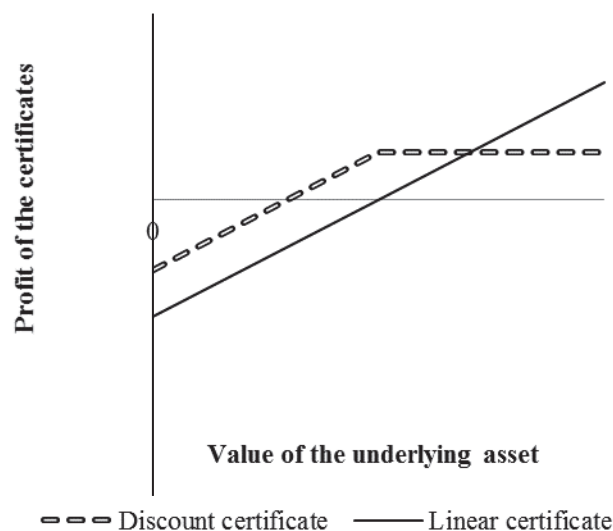
Discount certificates enable conservative investors to participate in more profitable investments with a partial risk protection. Discount certificates are characterized by being sold with a discount for a fair value k_0 . It means that the investor buys a discount certificate for k_0 , which is always lower than the actual underlying asset price S_0 . Cap level C is the highest possible participation in the growth of the underlying asset price. It is set at the time of issue of a discount certificate and it is valid throughout the certificate validity period. Further, the profit depends on the multiplier p (often 0.01 or 0.001). If an underlying asset has the actual price of 10,000 points, then the most probable multiplier is 0.001 and the fair value of the certificate is 10 units. The certificate price is thus available even for small investors identified as retail clients.

The profit function of a discount certificate with the underlying asset price at the maturity date S_T is as follows:

$$P(S_T) = \begin{cases} p \cdot S_T - k_0 & \text{if } S_T < C, \\ p \cdot C - k_0 & \text{if } S_T \geq C. \end{cases} \quad (1)$$

The graph of the discount certificate profit function is given in the Figure 1. If the underlying asset price at the maturity date of the discount certificate is higher than cap level, then the investor receives the payoff $p \cdot C$ from the issuer. It is the maximum value which the investor can get for the discount certificate at the maturity date. If the underlying asset price at the maturity date is lower than cap level, then the investor receives the payoff $p \cdot S_T$. The profit from the linear certificate is $p \cdot S_T - k_0$ and the fair value is $k_0 = p \cdot S_0$.

Figure 1 The graph of the discount certificate profit function



The profit of a discount certificate can be replicated from holding following alternative portfolio:

- a long position in the number of p underlying asset with the actual price S_0 and the price at the maturity date S_T

$$P_1(S_T) = p \cdot S_T - p \cdot S_0, \quad (2)$$

- a short position in the number of p call options on the same underlying asset with the strike level referred to the cap level C , the premium p_{SC} for an option and the maturity date identical with the discount certificate's maturity date

$$P_2(S_T) = \begin{cases} p \cdot p_{SC} & \text{if } S_T < C, \\ -p \cdot (S_T - C - p_{SC}) & \text{if } S_T \geq C. \end{cases} \quad (3)$$

Profit function from the alternative portfolio expressed as the sum of the individual positions (2) and (3) has the following form:

$$P(S_T) = \begin{cases} p \cdot (S_T - S_0 + p_{SC}) & \text{if } S_T < C, \\ p \cdot (C - S_0 + p_{SC}) & \text{if } S_T \geq C. \end{cases} \quad (4)$$

If the following formula is met:

$$k_0 = p \cdot (S_0 - p_{SC}), \quad (5)$$

then the profit function of the alternative portfolio (4) is identical to the profit function of the discount certificate (1). Any selling price of the certificate above the fair value k_0 is the gain to the certificate issuer. Two variants of the underlying price development can occur at the maturity date of a discount certificate. If the price at the maturity date is lower than the cap level, the profit from discount certificate is $(p \cdot S_T - k_0)$. If the price at the maturity date is higher than the cap level, the investor will obtain fixed profit $(p \cdot C - k_0)$ and he cannot participate in the price increase.

1.2 METHODOLOGY - TWO-ASSET CORRELATION OPTION AND ITS VALUATION

Two-asset correlation options are multiple asset options. As the name implies, they are options whose payoff is based on two underlying assets with two strike prices. The two assets are associated with one another through their correlation coefficient.

A two asset correlation call option on two assets with the prices at the maturity date S_{T1} and S_{T2} and the strike prices X_1 and X_2 has a payoff of $\max(S_{T2}^2 - X_2, 0)$ if $S_{T1}^1 > X_1$ and 0 otherwise, and a put option has a payoff of $\max(X_2 - S_{T2}^2, 0)$ if $S_{T1}^1 < X_1$ and 0 otherwise.

The profit function of a buying two asset correlation call option with an option premium p_{BC} at the maturity date is

$$P(S_{T1}^1, S_{T2}^2) = \begin{cases} -p_{BC} & \text{if } S_{T1}^1 < X_1, \\ S_{T2}^2 - X_2 - p_{BC} & \text{if } S_{T1}^1 \geq X_1. \end{cases} \quad (6)$$

The profit function of a buying two asset correlation put option with an option premium p_{BP} at the maturity date T has the form

$$P(S_T^1, S_T^2) = \begin{cases} X_2 - S_T^2 - p_{BP} & \text{if } S_T^1 < X_1, \\ -p_{BP} & \text{if } S_T^1 \geq X_1. \end{cases} \quad (7)$$

It can be seen that the profit depends on the spot prices of both assets at the maturity date of options. It is valid, the profit function can be expressed either as the first asset from the basket depending on the second asset price development or vice versa as the second asset depending on the first asset price development. In this paper we consider only the first variant.

Due to the lack of real-traded two asset correlation option data we calculate the option premiums using the analytical formulas of Zhang (1995):

$$p_C = S_2 e^{(b_2 - r)T} M(y_2 + \sigma_2 \sqrt{T}, y_1 + \rho \sigma_2 \sqrt{T}; \rho) - X_2 e^{-rT} M(y_2, y_1; \rho), \quad (8)$$

$$p_P = X_2 e^{-rT} M(-y_2, -y_1; \rho) - S_2 e^{(b_2 - r)T} M(-y_2 - \sigma_2 \sqrt{T}, -y_1 - \rho \sigma_2 \sqrt{T}; \rho), \quad (9)$$

$$y_1 = \frac{\ln(S_1 / X_1) + (b_1 - \sigma_1^2 / 2)T}{\sigma_1 \sqrt{T}}, \quad (10)$$

$$y_2 = \frac{\ln(S_2 / X_2) + (b_2 - \sigma_2^2 / 2)T}{\sigma_2 \sqrt{T}}, \quad (11)$$

where r is the risk-free interest rate, t is the time to maturity, σ is the volatility, $M(a, b; \rho)$ is the function of two-dimensional normal distribution, y_1 and y_2 are the returns on the two assets and ρ is the correlation coefficient between these returns. The problem of evaluating the pricing of basket options through the effect of correlation and transactions costs is dealt by Atkinson and Ingpochai (2012).

2. PROPOSAL OF NEW INVESTMENT CERTIFICATE

Let us create the portfolio as a combination of

- a long position in the stock with the starting price S_0^2

$$P_1(S_T^2) = S_T^2 - S_0^2, \quad (12)$$

- a short position in the two-asset correlation call option on the underlying asset (basket of two stocks)

$$P_2(S_T^1, S_T^2) = \begin{cases} p_{SC} & \text{if } S_T^1 < X_1, \\ X_2 - S_T^2 + p_{SC} & \text{if } S_T^1 \geq X_1. \end{cases} \quad (13)$$

The profit function of the portfolio expressed as a sum of individual profit functions (12) and (13) has a form

$$P(S_T^1, S_T^2) = \begin{cases} S_T^2 - S_0^2 + p_{SC} & \text{if } S_T^1 < X_1, \\ X_2 - S_0^2 + p_{SC} & \text{if } S_T^1 \geq X_1. \end{cases} \quad (14)$$

If we denote the fair value of the new discount basket certificate k_0 and the following formula is met

$$k_0 = S_0^2 - p_{SC}, \quad (15)$$

then the profit function of the new discount basket certificate can be derived as

$$P(S_T^1, S_T^2) = \begin{cases} S_T^2 - k_0 & \text{if } S_T^1 < X_1, \\ X_2 - k_0 & \text{if } S_T^1 \geq X_1. \end{cases} \quad (16)$$

Any price of the new discount basket certificate above the fair value is the gain to the certificate issuer. At the maturity date, the profit from the new discount basket certificate can have two possible variants depending on the assets' price development. The investor has a payoff of $\max(S_T^2 - k_0, 0)$ if the price at the maturity date of the first asset from the basket is above the strike price of and $\max(X_2 - k_0, 0)$ otherwise. The profit function of the new discount basket certificate can be replicated by a long position in the basket of stocks and a short position in the two-asset correlation call option on the same basket.

3. APPLICATION ON THE INTERNET INDUSTRY

In this section, we propose new discount basket certificate on two assets with different levels of its parameters and perform the analysis of the profitability for to the investor at the maturity date. We are going to show which parameters the investor should pay attention to when deciding to invest into the given investment certificate. We will use European style two-asset correlation options in the creation of new investment certificate.

3.1 Data

Options are the significant part of every investment certificate, therefore our analysis must be based on these instruments. There is not a derivative market for two asset correlation option. Due to the lack of market two asset correlation option prices, the values of the option prices was calculated in the software environment for statistical computing and graphics Project R using a pricing formula of Zhang (1995). The basket of two stocks from the internet industry Facebook and Google was selected for the underlying variable. The data consists of actual prices, historical daily prices for analysed time period and classical call option prices of stocks Facebook and Google from the U.S. market.

Two asset option prices on the given basket depend on the input parameters such as the actual prices of the underlying variables, the strike prices, the implied volatilities, the maturity date, the risk-free interest rate, the correlation coefficient. The price of the stock Facebook reached a value of 95.81 USD in October 16, 2015. The price of Google on October 16, 2015 was 657.54 USD. Facebook and Google do not pay dividends at the moment. The strike prices selected according to the strike prices of classical options are in the range of 70-120 USD for the stock Facebook and 635-685 USD for the stock Google. Lower the strike prices of call options, higher the option premium and vice versa. Therefore we have not selected very low and high levels. The strike prices for the stock Facebook are in the range of 66-95 USD. For the stock Google are in the range of 485-690 USD. The implied volatilities and the maturity date, specifically November 17, 2017, were similar as the classical options. The risk-free interest rate (0.2646%) is the yield of government bonds with similar maturity from the Bloomberg. The correlation coefficient (0.636) is calculated based on known formulas. These parameters impact on the two asset option prices and on the new investment certificate's profit too. The dataset used in our analysis can be provided upon request.

The common key data for the proposed new discount basket certificate are presented in the Table 1. We implement the multiplier 0.1.

Table 1. Common data about new discount basket certificate

<i>Parameter/Underlying</i>	<i>Facebook</i>	<i>Google</i>
Underlying price (S_0)	95.81 USD	657.54 USD
Issue date (T_0)	16/10/2015	16/10/2015
Maturity date (T)	17/11/2017	17/11/2017

3.2 RESULTS

Let us propose the new discount basket certificate as a combination of a long position in the stock Google with the starting price 657.54 USD and a short position in two-asset correlation call option on Facebook with the strike price 95 and Google with the strike price 660 and option premium 63.29 USD.

The profit function of the new discount basket certificate at the maturity date using the formula (14) is represented by the following equation:

$$P(S_T^1, S_T^2) = \begin{cases} 0.1S_T^2 - 59.43 & \text{if } S_T^1 < 95, \\ 6.58 & \text{if } S_T^1 \geq 95. \end{cases} \quad (17)$$

The fair value of this certificate based on (15) is 59.43 USD.

Let us propose the new discount basket certificates on Facebook and Google with various strike prices. This parameter impacts on the profit of the potential investor. The Table 2 shows the proposed new discount basket certificates for further analysis. The fair values of each certificate are calculated using the formula (15). We suppose that the issue prices are the same as the fair values.

Table 2 Parameters of the proposed new discount basket certificates and their issue prices

<i>Denotation</i>	<i>Strike prices for Facebook</i>	<i>Strike prices for Google</i>	<i>Call two-asset option premium</i>	<i>Fair values</i>
l_1	70	635	92.64	56.49
l_2	70	660	79.40	57.81
l_3	70	685	67.66	58.99
l_4	95	635	72.45	58.51
l_5	95	660	63.29	59.43
l_6	95	685	54.97	60.26
l_7	120	635	47.92	60.96
l_8	120	660	42.56	61.50
l_9	120	685	37.63	61.99

We evaluate the profitability of the new discount basket certificates l_5 and l_6 from the investor's point of view. The comparison of their profits at possible future scenarios of underlying prices' development is illustrated in the Figures 2 and 3. If the value of Facebook is lower than 95 at the maturity date, then the new discount basket certificate l_5 is the best variant, otherwise the new discount basket certificate l_6 is the adequate choice. The results indicate that the new discount basket certificate l_5 as well as the new discount basket certificate l_6 may generate the maximum profit. Therefore, it is important to select the certificate with the most appropriate parameters based on investor's expectation of underlying's price development.

Figure 2. Profit of the new discount basket certificates I₅ and I₆ if the value of the stock Facebook at the maturity date is lower than the strike price 95

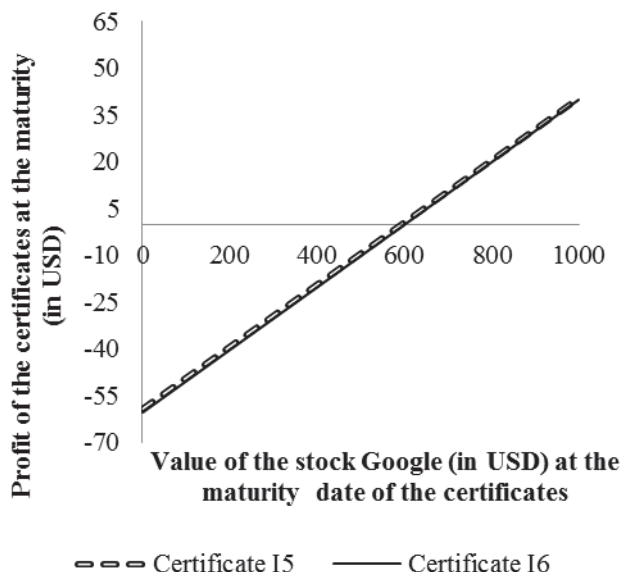
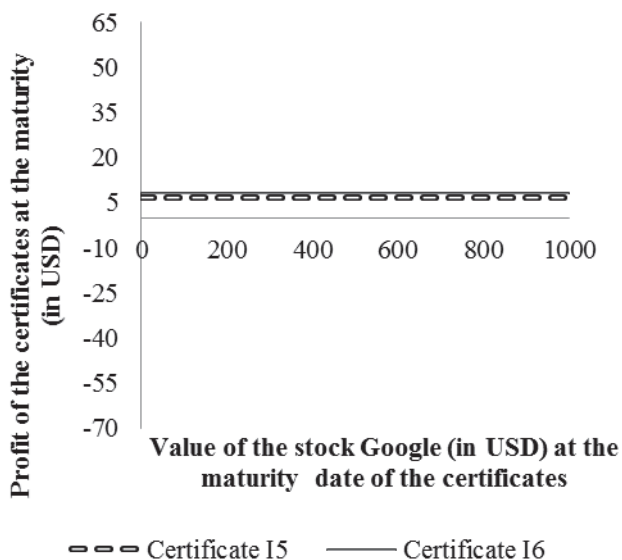


Figure 3. Profit of the new discount basket two-asset certificates I₅ and I₆ if the value of the stock Facebook at the maturity date is higher than the strike price 95



Profitability analysis of the proposed certificates for the intervals of Facebook values and the values of Google at the maturity date is displayed in the Tables 3, 4, 5 and 6. A scale of 1 to 9 is used for the profit ranking where 1 means the best certificate. If the Facebook value at the maturity date is lower than 70 then the profit for the investor takes values from the Table 3. It can be seen that the new discount basket certificate I₁ ensures the highest profit for all expected intervals of Google values at the maturity date. Therefore, we recommend the new discount certificate for these assumptions.

Table 3. Profitability analysis of the proposed new discount basket certificates if $S_1^T < 70$

IC	I1	I2	I3	I4	I5	I6	I7	I8	I9
Google values at the maturity date	Profit from the certificate at the maturity date								
0	-56.41	-57.81	-58.99	-58.51	-59.43	-60.26	-60.96	-61.5	-61.99
635	7.09	5.69	4.51	4.99	4.07	3.24	2.54	2	1.51
660	9.59	8.19	7.01	7.49	6.57	5.74	5.04	4.5	4.01
685	12.09	10.69	9.51	9.99	9.07	8.24	7.54	7	6.51
1000	43.59	42.19	41.01	41.49	40.57	39.74	39.04	38.5	38.01
Ranking	1	2	4	3	5	6	7	8	9

The results from the Tables 4 and 5 indicate that it is not possible to specify the same ranking for all scenarios of Google price development at the maturity date. The ranking needs to be done for the individual intervals of Google values. The complex analysis can be provided upon request.

The profit of the investor from the given certificates with the Facebook value at the maturity date from the interval $70 \leq S_1^T < 95$ is in the Table 4. If the price of Google at the maturity date is lower than 680.2, then the new discount basket certificate I₃ is the best variant, otherwise, the new discount basket certificate I₄.

Table 4. Profitability analysis of the proposed new discount basket certificates if $70 \leq S_1^T < 95$

IC	I1	I2	I3	I4	I5	I6	I7	I8	I9
Google values at the maturity date	Profit from the certificate at the maturity date								
0	7,01	8,19	9,51	-58,51	-59,43	-60,26	-60,96	-61,5	-61,99
635	7,01	8,19	9,51	4,99	4,07	3,24	2,54	2	1,51
660	7,01	8,19	9,51	7,49	6,57	5,74	5,04	4,5	4,01
680,2	7,01	8,19	9,51	9,51	8,59	7,76	7,06	6,52	6,03
Ranking			1						
685	7,01	8,19	9,51	9,99	9,07	8,24	7,54	7	6,51
1000	7,01	8,19	9,51	41,49	40,57	39,74	39,04	38,5	38,01
Ranking				1					

If the price of Facebook is from the interval $95 \leq S_1^T < 120$, then the new discount basket certificate I₃ ensures the highest profit for the price of Google lower than 704.7 and the new discount basket certificate I₇ for the price of Google higher than 704.7.

Table 5. Profitability analysis of the proposed new discount basket certificates if $95 \leq S_1^T < 120$

IC	I1	I2	I3	I4	I5	I6	I7	I8	I9
Google values at the maturity date	Profit from the certificate at the maturity date								
0	7,01	8,19	9,51	4,99	6,58	8,24	-60,96	-61,5	-61,99
635	7,01	8,19	9,51	4,99	6,58	8,24	2,54	2	1,51
660	7,01	8,19	9,51	4,99	6,58	8,24	5,04	4,5	4,01
680,2	7,01	8,19	9,51	4,99	6,58	8,24	7,06	6,52	6,03
685	7,01	8,19	9,51	4,99	6,58	8,24	7,54	7	6,51
704,7	7,01	8,19	9,51	4,99	6,58	8,24	9,51	8,97	8,48
Ranking			1						
1000	7,01	8,19	9,51	4,99	6,58	8,24	39,04	38,5	38,01
Ranking							1		

If $S_1^T \geq 120$ is higher than 120, then the profit for the investor takes values from the Table 6. Based on the performed profitability analysis of the proposed new discount basket certificates we report the following finding. The new discount basket certificate I_3 ensures the highest profit for the investor.

Table 6. Profitability analysis of the proposed new discount basket certificates if $S_1^T \geq 120$

IC	I1	I2	I3	I4	I5	I6	I7	I8	I9
Google values at the maturity date	Profit from the certificate at the maturity date								
0	7,01	8,19	9,51	4,99	6,58	8,24	2,54	4,5	6,51
635	7,01	8,19	9,51	4,99	6,58	8,24	2,54	4,5	6,51
660	7,01	8,19	9,51	4,99	6,58	8,24	2,54	4,5	6,51
680,2	7,01	8,19	9,51	4,99	6,58	8,24	2,54	4,5	6,51
685	7,01	8,19	9,51	4,99	6,58	8,24	2,54	4,5	6,51
704,7	7,01	8,19	9,51	4,99	6,58	8,24	2,54	4,5	6,51
1000	7,01	8,19	9,51	4,99	6,58	8,24	2,54	4,5	6,51
Ranking	4	3	1	7	5	2	9	8	6

4. DISCUSSION

Note that some certificate may be the best for one scenario of the underlings' price development but the worst for another scenario. Therefore it is important to select the certificate based on investor's expectation of underlings' price development. The strike prices, the multiplier and the maturity date are specified at the time of the issue. These parameters impact on the profit of the investor. Due to this fact it is also important to select the certificate with the most appropriate parameters. These new financial innovations present an interesting way for investors how to invest money. On the other side, the issuers (banks and also governments) can gain resources for financing of their activities.

CONCLUSION

This paper is focused on the creation of the new discount basket certificates as the new tool for financing of issuers and investment for investors. These financial innovations are issued by financial institutions, mainly banks, but there is possible to utilize for financing of the fiscal imbalance. On the other side, these products are an interesting way how to invest money.

Design of these products is expressed through the analytical expression of European two-asset correlation options. For understanding of investment certificates' design, it was introduced the review of the literature dealing with the structured products. We propose new discount basket certificates followed theoretical background of the structured products based on financial engineering and options. This new product introduces new way for deposit free resources for investors with possibility of making a profit on slightly decreasing, stagnant and slightly increasing market dealing with basket stocks. On the basis of the existing empirical studies, the scientific problem of the paper is to design and demonstrate the nature of the new discount basket certificates creation through financial engineering. The approach is based on the pricing models of using two-asset correlation options.

Our empirical approach is applied on the basket stocks in the internet industry, where several certificates on Facebook and Google with various parameters are designed, compared and analysed followed by investigation of their profitability. Alternative investments using European two-asset correlation option prices from 16th October 2015 are presented. Due to lack of two-asset correlation option we calculated their prices according to Haug model.

By means of financial engineering and the analytical expression of the options there are proposed new approaches of the investment certificates creation. The main aim of the paper is to prove the nature of these products creations through the option strategies, which can be used for financing of issuers, not only for banks, but also for governments. On the other side, this approach is interesting also with the increasing of the intellectualization of all potential investors in Europe. According to the methodological point of view, our approach can provide as an inspiration for creation of the further types of the investment certificates for example with using American style of options.

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